Green Buildings - a Solution to India's high Energy Consumption

Abstract:

This paper is to bring into knowledge, a proficiency, which would help us to fight against energy crises using new construction techniques. It discusses the needs and benefits of sustainable Green buildings. It focuses on coming up with new ideas to build green buildings with minimum Embodied Energy. High energy conservation in buildings can be achieved by insulating materials (powerful device for designing and building) and by improving the construction envelope heat safety, which then controls the building envelope's transmissivity. Since the orientation of buildings and their protection from the sun cannot be implemented freely in the urban environment where it is densely built, heat insulation and adoption of bioclimatic architectural principles becomes the need. Green buildings, at the decreased ranges of consumption of resource and energy, the design of green buildings will meet the needs of users. This is a wise approach to use India's energy in this period of crisis. These buildings will replace most of our present building methodologies. "Energy can neither be created nor destroyed", hence application of this paper is aimed at utilizing the irrelevant energy consumed in building processes and providing comfort at the cost of sustainability.

Keywords:
Sustainable Green Buildings, Embodied Energy, High energy conservation, Thermal insulation, Bioclimatic architectural principles, Sustainability.

1.0 Introduction

The motive of this research was to analyze the composition of environment friendly office buildings and detached houses. These are acknowledged as sustainable, green structures which characterize pleasant constructions that notably minimize the effect on environment. As the price of natural resources and energy continue to rise, this subject becomes more applicable. In India, the greatest supply for the use of energy is represented by buildings. In contrast to greenhouse gas emission by industries (25%) and transportation (32%), the buildings are estimated to emit 43% of greenhouse gas (World Green Building Council).

The design of green buildings helps in minimizing or removing the effect on natural environment as well as human health. This is carried out with the aid of operational compositions and incorporating substances that are environmentally accountable and aid environment friendly for the entire duration of the buildings (U.S Environmental Protection Agency, 2016).

As the life cycle of green buildings have wider effect on the community, it attracts greater interest towards it. The life cycle of green building is defined as the life expectancy of all the components that forms the structure and the effect on functioning of structure over a set period of time. Life cycle additionally consists of the entire effect on society in phrases of environment friendly green building and any related contributions that is made by the environment (Khasreen, Banfill, & Menzies, 2009). Figure 1 shows the life cycle of a building (Aytac, Arslan, & Durak, 2016).

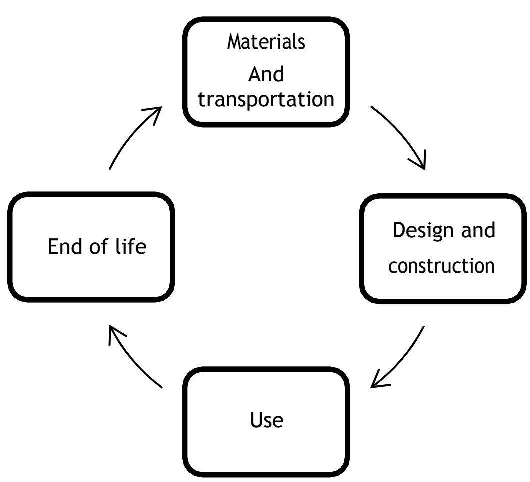

Figure 1: Life cycle of a Building

1.1 Definitions

Sustainability – *"Development that meets the needs of present generations without compromising the ability of future generations to meet their own needs"* (UNAI).

Carbon Footprint – *"It is defined as the measure of the exclusive global amount of carbon dioxide (CO_2) and other greenhouse gasses emitted by a human activity or accumulated over the full life cycle of a building"* (Youmatter, 2020).

High-Performance Building – *"It is defined as a structure that is energy efficient has low-term and long-term life-cycle costs, is healthy for its occupants, and has relatively low impact on the environment"* (Yuksek & Karadayi, 2017).

Sustainable construction – *"Sustainable construction aims at reducing the environmental impact of a building over its entire lifetime, while optimizing its economic viability and the comfort and safety of its occupants"* (WBDG Sustainable Committee, 2021).

1.2 Focus

The shift in green buildings has been concentrated on the building itself, in the past. However it is now aiming at the whole method to involve a point of view of the larger group and on the international influence (World Green Building Council). Previously it was believed that just saving electricity and proper utilization of water and some other resources made it a *Green Building*, but new researches and my study have brought me to a conclusion that if we want to build a green building then first step should be taken right from planning procedure. Around the globe, nations are initiating to outline the necessities for sustainable buildings. Their aim is to reduce CO_2 emissions and usage of energy (Ahmeti, Sylejmani, & Aliu, 2016).

This paper focuses on the contribution of transportation, extraction, construction methodology, new building materials, and new designs in building sector to reduce overall consumption of energy and minimal emission of CO_2.

1.3 Purpose

Minimization in the cost of energy, air quality enhancement and refining the usage of resources and materials utilized in building construction are the motive behind green building technology. Green building is created, constructed, rejuvenated, handled and reused in an energy saving manner, this it is regarded as safe and environment friendly building. But the most vital is to control the influence the building will have on environment. The cause of orderly use of energy to decrease the costs as well a dependence on natural resources (World Green Building Council).

1.4 Background

Nowadays the phrase, "Green " or " Going Green " is turning out to be familiar and is described differently based on the outlook. Green can be utilized to mention the way the products are made or the composition of products. Green can be stated to be replaced by sustainability, by lessening the demands on natural assets, eventually community will secure a place in the international recycling programs in society is also regarded as green.

Historically, Green revolution was associated with agriculture and was regularly referred to as the "Green Revolution" the "New Green Revolution" is meant to make constructions and community's eco-friendly in order to be sustainable for the future (Zigenfus, 2008).

2.0 A journey to achieve "Green"

Planning the building is the most basic procedure we have to pass through. It involves three basic stages i.e. Material production, Construction, and Demolition. Now talking about present building planning, we come across many new terminology and data like sustainable, energy efficient, different building materials etc.

2.1 Sustainable development

Sustainable development is an advancement which addresses the issues of the present without compromising the capacity of future generations to address their own issues (UNESCO, 2021).

The definition is based on two ideas (Mensah, 2019):

- The idea of necessities, including the conditions for keeping an adequate life ideal for all people.
- The idea of limits of the capability of the surrounding to fulfill the necessities of the current and the future, controlled by the condition of innovation and social association.

2.2 Embodied Energy

The amount of energy needed by every one of the activities related with a creation interaction, including the general extents devoured in all activities upstream to the procurement of natural resources and the portion of energy utilized in making hardware and other supporting capacities. For example direct plus indirect energy (Ambrose & Burn, 2005)..

The energy input needed to convey, transport and assembling building materials, in addition to the energy utilized in the development cycle, can add up to a fourth 'lifetime' energy necessity of a very energy-effective structure (Ambrose & Burn, 2005).

2.3 Common Building Materials

This counts the conventional materials used for building purposes like burnt clay brick, concrete, cement, steel, sand, and many more. Now, the scenario of Indian buildings and construction depicts the following fact,

Table 1: Common Building Materials

Common Building Materials
Burnt Clay Bricks
Stone, Concrete Blocks
Cement, Steel , Concrete
Aluminum, Zinc
Glass
Tiles
Plastic, PVC, Paint and Timber

Table 2: Material consumed by India[1]

Materials consumed in bulk quantities		
Type of Material	**Current annual Utilization (10^6)**	**Yearly Utilization till 2020 (10^6)**
Burnt Clay Bricks	170 X 10^3 Nos	260 X 10^3 Nos.
Cement	110 tones	260 tones
Structural Steel	12 tones	25 tones
Coarse Aggregates	300 m^3	750 m^3
Sand	300 m^3	750 m^3

Table 1 shows the common materials used to construct buildings in India and Table 2 (Reddy, 2009) shows the consumptions of these materials in India.

2.4 Present scenario of India

The greater parts of Indian buildings are particularly disparate in plan approach than the buildings in developed nations. Developers and designers have a thought of rating framework that adjusts to Indian ecological conditions and meet the needs for stock of Indian buildings. For example, the global rating framework are created around the reason that the buildings are cooled, while in India, enormous number of buildings worked so far are either non-cooled or partially cooled. GRIHA (Green Rating for Integrated Habitat Assessment) was developed by TERI, to connect the interest for rating framework for non-cooled buildings and one that considered the chance of a partially cooled buildings as well. This system reacted explicitly to India's focused on public concerns, for example, outrageous resource collapse in the sector of water and power and quick dissolving biodiversity. It endeavored to stress on sun powered passive procedure for enhancing indoor visual and heat comfort and depending on refrigeration based cooling frameworks just in instance of outrageous discomfort (Bee Policy India).

Nonetheless, this framework has just been produced for the biggest forthcoming energy consuming section, for example, business, private buildings and institutions and a similar standardized currently being developed to meet the requirements of other types of buildings for example existing structures, industrial structures and so on (Bee Policy India).

2.5 Energy of Buildings:

This can be categorized into two parts (Reddy & Jagdish, Embodied energy of common and alternative building materials and technologies, 2003):

1. Energy functioning and maintaining.
2. Embodies energy
   i. Material production
   ii. Transportation of material
   iii. Assembling into buildings

1.6 Sustainably managed materials:

(EL Khouli, John, & Zeurnu, 2015) A sustainably managed building material is the one which is environment friendly. Its utilization in a natural obligation in commitment towards a maintainable living space. There materials have five significant advantages:

1. They have a comparative or lower values contrasted with conventional materials.
2. Depletion of current supplies of limited materials is none.
3. Declaring harmful emissions and saving of energy.

4. Permissions for planning are bound to be obtained as they are empowered by the building control.
5. They make better and healthy buildings as they are less harmful for tenants.

1.6.1 Cement/concrete

- *Pre-cast hollow concrete blocks*
  These are produced by utilizing lean cement blends and expelled through block – production machines of static sort. Cement mortar is required in lesser amount and in contrast with block stonework, they empower quick construction and the empty space in block gives better heat insulation and needn't bother with outer/ interior plastering (Mishra, 2013).

- *Fly ash-based lightweight aerated concrete blocks*
  Manufacturing of these concrete blocks are for the purpose of roofing and walking. These blocks are produced by blending fly ash, quick lime or concrete gypsum with frothing agent. These are regarded as fantastic for roofing as well as walking as they are made up of fly ash which is a waste from thermal power plant (Mishra, 2013).

- *Ferrocement*
  The composite if Ferrocement framework is easy to build and constitute rich mortar supported wire mesh (welded). This helps in reduction of thickness of wall and permits wide-ranging areas. The energy of this system is 13% to the energy of simple cement system on this place. This type of construction technique is best suitable for seismic areas (TERI, 2004).

2.6.2 Masonry units

2.6.2.1 Clay fly ash burnt

The main constituents which produce clay fly ash are clay and fly ash. Compared to burnt clay bricks, which is made conventionally, burnt bricks made of clay fly ash are considered to be stronger. The energy consumed by this brick is 75% less and it provides better heat insulation are ecologically effective (TERI, 2004).

Industrial waste used: Fly ash is used which is waste from thermal power plant.

Percentage weight (w %): Clay 15% - 30% and Fly ash up to 66%.

Characteristics: Bulk density is reduced to 1.6 g/m^3. Compressive strength is increased by 50% - 60%. And average compressive strength of 7.5-20 Mpa.[2]

2.6.2.2 Fly ash/sand lime bricks

Productions of this bricks are made from sand or fly ash with like as binder. These bricks are hefty, better in absorbing water and pulverizing strength, but there is a need of autoclaving (TERI, 2004). The cycle includes, high or low pressure compaction followed by low tension steam restoring autoclaving under raised aqueous conditions (Neenu, 2020).

Industrial waste used: Fly ash, lime

Percentage weight (w %): Fly ash or sand 30% - 65% and lime 15% - 35%.

Characteristics: Reduces the drying time, increases the workability, has lower water absorption and has high crushing strength of 10-25 Mpa (TERI, 2004).

2.6.2.3 Coal shale bricks

These are used in a pulverized form as an additive to the lean and moderately plastic micaceous clay overlaying the Gangetic plains to prepare bricks with high compressive strength and low water absorption.

Industrial waste used: Coal shale contains 75% - 80% of siliceous/mineral rejected from coal washers.

Percentage weight (w%): Pulverized shales about 25% - 50%.

Characteristics: Yields a compressive strength of 10-25 Mpa, water absorption capacity of 6% - 15%

2.6.2.4 Compressed earth blocks

System of construction: For a cost efficient, environmentally friendly stonework system, the compressed earth block innovation is found to be one of the methods. The wide range of application can be found from the product (stabilized blocks) i.e., for roofing, angled openings, wall cladding, roofing sheets and so on. These blocks (stabilized blocks) are produced by blending of crude earth with a stabilizer (lime or cement) at a certain pressure (20-40 Kg/cm^2) by a mechanized or manual soil press (Niazi, Khanna, Gupta, & Sirohi, 2020).

Equipment: India has many hand operated and water powered machines. The fundamental guidelines of all machine is to reduce crude earth to accomplish thick masonry units of the same size (Niazi, Khanna, Gupta, & Sirohi, 2020).

Shape: The shape of these stabilized blocks are cuboidal, which might be rigid, hollow otherwise interlocked. The equipment utilized in its production shall determine the form and size of the block. It tends to be utilized for load – bearing development of building up to these floors. The degree of stabilization has the most extreme effect on the expense of the product (Niazi, Khanna, Gupta, & Sirohi, 2020).

Raw material: Crude earth or soil is any essential material for the production, this is considered to be primary materials. Other elements like small amounts of cement and water are also used. Sand or residues of stone can be added relying upon the quality of soil. Soil is comprised of grains of different sizes. The stability for the production of compressed blocks is determined by the grain size arrangement of a soil (Niazi, Khanna, Gupta, & Sirohi, 2020).

Design and Construction: The basic design principles are a solid establishment with adequate tallness of base, adequate ceiling, finishing of a strong wall, accurate connections of joints and utilizing concrete elements, where these is an active stress. Other design considerations include the percentage of area of openings, which should not be greater than 15-20 percent (Niazi, Khanna, Gupta, & Sirohi, 2020).

The unique features of these compressed earth blocks are (Guettala, Bachar, & Azzouz, 2016):

- Inadequate energy and emission potential.
- Size is unvarying
- Durability is high
- Heat insulations
- Adaptable and economically efficient

Ratio*:* Thickness to height ratio should not exceed 1:16. The minimum thickness should be 8 inches.

Load bearing: a wall thickness of 23 cm up to three story is the usual load-bearing capacity, with lateral support system like reinforced concrete or wooden ring beams at the first floor level. Wooden or stone lintels are normally used over openings.

2.6.3 Roofing

2.6.3.1 Ferrocement roofing

Principle: Using of the plan standards or strengthened shells for roofing in the ferrocement technology, is regularly called channels. They are created on uniquely planned profiled molds and vibrating tables (TARA machines and tech services Pvt. Ltd, 2019).

Advantages*:* It is a viable alternative to conventional flat roofing systems such as RCC etc. Production of channels with optimal ratio of concrete, water and sand have a density which is exceptionally high, are impenetrable to infiltration of water and give high structural strength (TARA machines and tech services Pvt. Ltd, 2019).

Dimensions*:* These roofing channels of ferrocement have thickness of 2.5cm and the width of 83 cm, and it's length when it is mechanically produced can be 6m. With the help of intermediate support, duration of the roofing can be prolonged (Development Alternatives).

System of construction: The components used in manufacturing of ferrocement have fixed proportion of components like water, sand and cement to provide high strength mortar which is strengthened with 22 gauge galvanized iron chicken wire mesh layer and 8-12 mm (diameter) Tor steel bars at the base ribs of the channel. After restoring for 14 days, these ferrocement roofing channels can be securely transported (Development Alternatives).

Application: These roofing channels helps in speeding of the construction and it can utilized in constructions of houses, elementary schools and other local area buildings, verandas and carports, modern sheds, studios and warehouse, ranch houses and semi-covered buildings (Maharastra Engineering REsearch Institute, 2018).

3.0 Green Building Architecture

In India, main consumption of energy goes with acquiring comfort against the varied environment. So to achieve green buildings we need to overcome these issues. Following steps may lead us to energy efficient green building.

3.1 Innovative thermal insulation

To execute heat insulation in recently built structures, appropriate planning and design incorporate reasonable insulation measures with construction buildings, for example one of the compelling insulation procedure i.e., cavity wall insulation. Appropriately arranged insulation does not influence construction and building aesthetics. To the extent, improving of heat protection in existing structures is concerned the utilization of heat insulation is more complicated since there are beneficial and architectural limitations. These are continuous restrictions to the disturbances, permitted during the interior work of the buildings as well.

One more boundary in use of insulation is its expense. As insulation is manufactured to make more reasonable for implementing in building, for example, unbending sheets, mats and so on. But using insulating materials like thermocol and POP (Plaster of Paris) can overcome these barriers. Installing this insulation are cost effective, rapid and also easy. It does not influence the design and aesthetic appearance of building. This material used in insulation can possibly fulfill the insulation necessity in energy conservation building code.

Thermocol

Thermocol has the scientific name of polystyrene, usually implemented in extended form. It is manufactured from a combination of polystyrene (90-95%) and gaseous blowing agent (5-10%), generally CO_2 or pentane (Central Public Health ANDEnvironmental Engineering Organisation (CPHEEO), 2016). When the air is trapped in the voids, it results in low thermal conductivity (Wikipedia). In the past, thermocol contained CFCs, however, nowadays blowing agents which are environment friendly are used as well (Encyclopedia). Thermocol different in their density incredibly from about 25-200 kg/m^3 , based on the amount of gas that is mixed to make the forth. With a not wire froth cutter, thermocol can be removed effectively(Wikipedia).

Plaster of Paris Sheet

The main uses of POP sheets are for improving of roofs and dividers and gives surface with smooth finish. It is utilized to help the thermocol and furthermore to acquire smooth finished surface which would if not given by thermocol. With utilization of POP sheets, the additional expense can be saved which is induced for smooth surface (Wikipedia).

Methodology

A significant factor during execution of energy conservation building code is determination of thickness for insulation sheet. Standard U-factor needed for energy code can be satisfied by specific insulation thickness. Figure 2 shows the study model of building that was constructed and to accomplish standard U-factor pre-requisite of code, thermocol with different thickness is applied. For example, sample estimation was made for 'total U-factor for thermocol of thickness 2cm and POP sheet of 1cm as shown in equation 1 (Bureau of Energy Efficience, 2017).

Thermocol and POP Sheet[3]

Heat conduction of thermocol = 0.275 W/m^{o}C

Heat conduction of plaster of Paris = 17.5 W/m^{o}C

Let us consider,

Thermocol sheet thickness = 3 cm and

POP sheet thickness = 1 cm

U-factor:

Thermocol sheet = 0.0275/0.03 = 0.92 W/ m^2 ^{o}C

POP sheet = 0.175/0.01 = 17.5 W/m^2 ^{o}C

$$U_{total} = \frac{1}{1/U_{thermocol} + 1/U_{PoP\ sheet}} \quad (1)$$

or, U_{total} = 0.87 W/m^2 ^{o}C

Using a different thickness of thermocol and POP sheets, an estimated values of U_{total} are given in Table 8. It is seen from the table that thermocol with thickness 7.5cm with POP sheets of 1 cm fulfill the necessity for insulation.

Table 3: Thickness and U-value of insulation [4]

Thermocol + POP sheet	U-value, W/m^2 ^{o}C
0.5 cm + 1 cm	4.18
1.0 cm + 1 cm	2.37
4.0cm + 1 cm	0.66

7.5 cm + 1 cm	0.35
8.0 cm + 1 cm	0.33

It is important to discover the relationship between temperature difference and the insulation, it produces among the inside and outside the structure/ building.

From testing the study model, furthermore this relationship has been created. This model is geometrically alike its model structure at the size 1:10. Figure 2 shows the idea of insulation pattern if study model. The window area has the same proportion as that of model, which was 1/5th of floor region. Four walls and the top of the model face the radiation front the sun. To each of the four sides, insulating materials is implemented and on the top of the model is a thermocol sheet and POP sheet of 1 cm thickness.

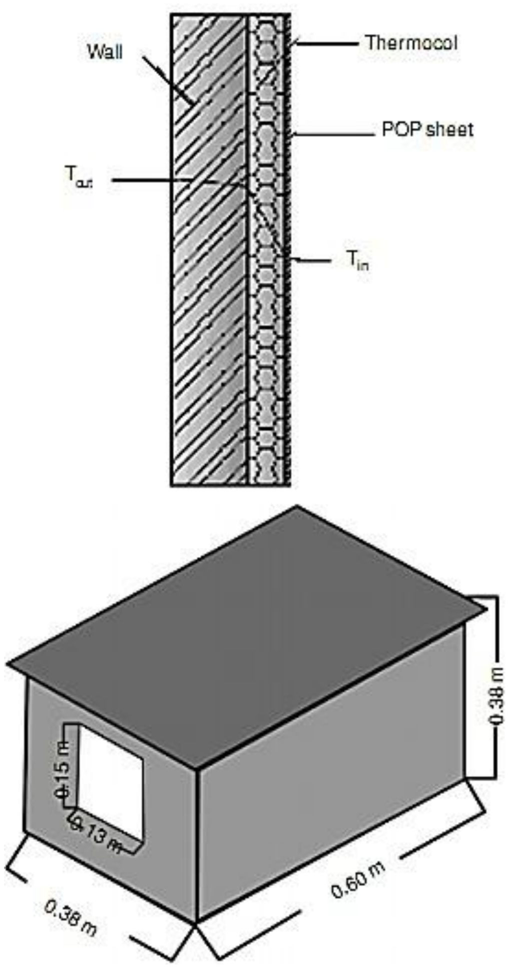

Figure 2: Concept of insulation and figure of study model[5]

Increase in thickness can be seen gradually with readings. At first, thermocol sheet of thickness 0.5 cm with a 1cm thick POP sheet was paced inside the model and temperature difference was measured with a thermometer for 5days from 9.00am to 5.00pm. In Figure 3, variation of difference in temperatures with the insulation of thickness and the values corresponding is recorded in Table 4. This relationship helps in evaluating the energy saving and significance of insulation.

Table 4: Temperature difference produced by insulation[6]

Cavity + POP sheet	Temperature difference(^{0}C)
1.5 cm + 1 cm	1.50
3.0 cm + 1 cm	2.00
5.0 cm + 1 cm	3.00
7.5 cm + 1 cm	4.92
10.0 cm + 1 cm	8.07

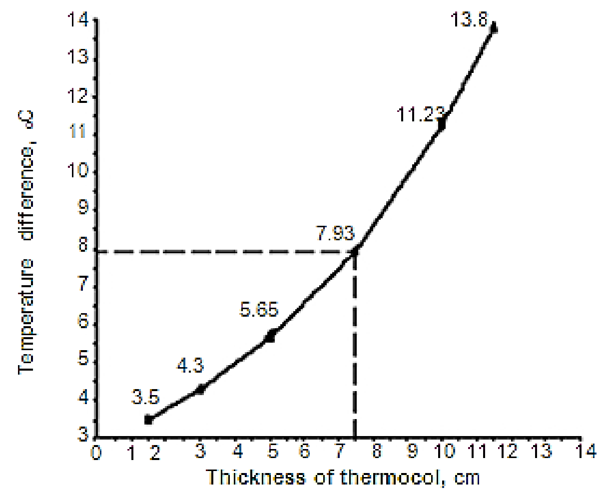

Figure 3: Variation of temperature difference with thickness of insulation[7]

Cost Analysis

The market review was accomplished for variable expense per product and the related expense are recorded in Table 5 for POP and thermocol sheet..

Table 5: Rate analysis of 7.5 cm thick thermocol with 1 cm POP sheet

Item	Rate/sq. ft, Rs.
7.5 cm thermocol sheet	16.00
1.0 cm POP sheet	6.00
light aluminium sections	3.00

POP finish	4.00
Cost of labour (30% on material cost	9.00
Total	**38.00**

4.0 Case study:

Here in case study of administrative building of Shivaji University, Kolhapur is reported from the paper, "Thermocol as Thermal Insulation: A Key Tool in Implementation of Energy Conservation Building Code of India" , by R H Patil. The main purpose of this case study is to use insulating materials that meets the requirement of the building code for energy conservation and to discover the energy savings. For this study, one of the rooms (Room no. 230) , measuring 13.4 m x 8.2 m with latitude 16^0 42' N and longitude 74^0 13' in the administrative building of Shivaji University, Kolhapur, Maharashtra was surveyed (Patil, 2008)

Data Collection

The room region of 110.42 m^2 and containing room divider and windows of 84.6 m^2 and 10.4 m^2 respectively. The building has stone work walls with external thickness of 0m6 m, RCC frame structure. This room has clear glass metal windows. For the last 32 years, the mean maximum temperature is 33.43 ^oC (Patil, 2008).

Cooling Load Calculation

The various parts of the cooling load incorporate the following. Through conduction, convection and radiation, the reasonable heat gain is eliminated, which can emerge from the following factor (Bhatia).

- Solar radiant heat hits the outside surface of walls, rooftops and glazing, which are absorbed and transferred inside.
- Heat carried in by infiltrating or ventilating outside air.
- Heat emitted by inhabitants.
- Heat emitted from lighting, cooking, engines, fans and industrial processed in an air conditioned space.

Latent heat gains are regarded when there is an expansion of water fukes to the inside air, which might have occurred from the following sources (Bhatia),

- Exterior air entering through penetration.
- From inhabitants.
- From clinking or industrial processes within the given space.

Table 6: Savings per unit area of building envelope

Content	Value
Area of building envelope, m^2	95
Saving in electrical energy, W	1300
Saving per unit area of building envelope, w/m^2	14

Table 7: Cooling load before application of insulation

Internal heat gain	Heat gain, W	Solar heat gain	Heat gain, W
Occupants • Sensible • Latent	 896.64 896.64	Opaque Walls	1426.83
Lighting	132.00	Windows • Heat of conductance • Radiant heat	 435.66 1709.48
Appliances • Fan • Computer • Printer	418.8		
Infiltration	10.54		
Total	**2354.62**	**Total**	**3571.97**
		Grand total	**5926.59**

Table 8: Cooling load after application of insulation

Internal heat gain	Heat gain, W	Solar heat gain	Heat gain, W
Occupants • Sensible • Latent	 896.64 896.64	Opaque Walls	221.66
Lighting	132.00	Windows • Heat of conductance • Radiant heat	 69.95 225.85
Appliances • Fan • Computer • Printer	418.8		
Infiltration	10.54		
Total	**2354.62**	**Total**	**547.46**
		Grand total	**2902.08**

Air conditioning (AC) system of 1 tomorrow corresponds to

3507 W of heat rejection. The calculation of the fooling load in Table 7, shows that split air conditioning system of 2 tons are needed for the room. In addition, the calculation of the cooling load after insulation is given in Table 8. Half of the cooling load can be minimized through insulation and this is shown in Table 8 as well. Therefore, air conditioning system of 1 ton is needed. This techniques economize a lot of electricity in addition to the expense of air conditioning equipment. In addition, saving per unit area of the building envelope is shown in Table 6. In prior to the using of the insulating materials in accordance with the calculation of the cooling load as seen in Table 7, installment of air conditioning appliances of 2 tons have already been done. Suppose the temperature is regulated to 20^0 C, then to reduce the internal temperature of 1^0 C from 35^0 to 20^0 C, 6.66% of the total electrical energy will be consumed by AC. It can be seen from Table 6 that the temperature of the inside building can be reduced by insulation by 7.92^0 C. The drop in temperature results in a reduction of load of 50% to 52% on the AC system. But it is depended on the AC system's thermol control and the functioning temperature scale.

5.0 Conclusions

The most important features of energy conservation building code is thermal insulation. In this article, an attempt was made to emphasize one such techniques by utilizing thermocol with Plaster of Paris sheet as thermal insulation material for the construction of external partitions. Based on the analysis of fooling load of the building, it could be deducted that cooling load was decreased to half of it by insulation of thermocol with POP sheet. This insulation material meets the insulation requirements of the building regulations for energy conservation. When applied to a building, this thermal protection technique is cost – effective, stable with a simple payback time of 3.47 years. This insulation helps in saving electricity of 14W per unit enclosure area.

This paper recommends and promotes the use of sustainably managed materials which are much superior to traditionally used bricks; cement etc. which have a very adverse effect on our fertile arable lands.

References :

Ahmeti, M., Sylejmani, M., & Aliu, V. (2016). Effects of sustainable materilas in construction,environmentand health. *UBT International Conferance.*

Ambrose, M., & Burn, S. (2005). Embodied energy of ppe networks. *Piipes Wagga Wagga*, 9.

Aytac, D. O., Arslan, J. V., & Durak, S. (2016). Adaptive reuse as a strategy toward urban resilience. *European Journal of Sustainable Development*, 523-532.

Bee Policy India. (n.d.). *India: The way towards energy and resource efficient buildings*. Retrieved from asiabusinesscouncil.org: http://www.asiabusinesscouncil.org/docs /B EE/papers/Bee_Policy_India.pdf

Bhatia, A. (n.d.). *Coling load calculations and principles*. Retrieved from CED Engineering: https:www.cedengineering.com/userfiles/C ooling520Load%20Calculations%20and %20P rinciples520R1.pdf

Bureau of Energy Efficience. (2017). *Energy conservation building code.* New Delhi: Bureau of energy efficience.

Central Public Health ANDEnvironmental Engineering Organisation (CPHEEO). (2016). *Part II : Manual on municipal solid waste management.* New Delhi.

Development Alternatives. (n.d.). *Ferrocement roofing technology*. Retrieved from 2.imimg.com: https://2.imimg.com/data2/UH/DC/M Y- 3007600/PRE-CAST-ROOFING-CANNEL- MKING-MACHINE.PDF

EL Khouli, S., John, & Zeurnu, M. (2015). *Sustainable Constructio Techniques:From Structural Design To*

Interior Fit-out:Assessing And Improving The Environmental Impact Of

Buildings. Institut fur Internationale Architektur Dokumentation.

Encyclopedia. (n.d.). *Polystyrene*. Retrieved from chemeurope.com: https://www.chemeurope.com/en/polyst yr ene.html

Green Technology, Technologies, Medical. (2012, April 15). Retrieved April Sunday, 2012, from http://www.nvudev.org: http://www.nvudev.org/green-building-technologies.html

Guettala, S., Bachar, M., & Azzouz, L. (2016). Properties of the compressed-stabilized earth bricks containing cork granules. *Journal of Earth Science and Climatic Change*, 353.

Khasreen, M. M., Banfill, P. F., & Menzies, G. F. (2009). Life-Cycle Assessment and the Environmental Impact of Buildings: A Review. *Sustainability*, 647-701.

Maharastra Engineering REsearch Institute. (2018). *Ferrocement Technology:WRD Handbook Chapter No. 1.* Nashik.

Mensah, J. (2019). Sustainable development:Meaning,history,principles, pill ars and implications for human action:literature review. *Cogent Social Sciences*.

Mishra, G. (2013). *Alternate building materials used in construction industry*. Retrieved from The Constructor: https://theconstructor.org/building/altern at e-building-materials/420/

Neenu, S. (2020). *Steam curing of concrete:Methods and Advantages*. Retrieved from The

Constructor: https://theconstructor.org/concrete/steam- curig-concrete-methods-advantages/

Niazi, Z., Khanna, P., Gupta, S., & Sirohi, R. (2020). *Stabilzed Compressed Earth Block(SCEB)- Production and Construction Guide.* New Delhi: Development Alternatives.

Patil, R. (2008). Thermocol as thermal insulation : A key tool in implementation of energy conservation building code of India. *Journal of the institution of Engineers (India):Architectural Engineering Division*, 26-30.

Reddy, B. (2009). Sustainable materials for low carbon buildings . *International Journal of Low Carbon Technologies* , 175-181.

Reddy, B., & Jagdish, K. (2003). Embodied energy of common and alternative building materials and technologies. *Energy and Buildings*, 129- 137.

TARA machines and tech services Pvt. Ltd. (2019). *Tara GreenCast Channels*. Retrieved from taramachines.com: https://www.taramachines.com/gc_channel s.aspx

TERI. (2004). *Sustainable building _Design manual.Volume 2.* The Energy and Resource Institute.

teri. (2004). *Sustainable building-Design Manual.* New Delhi: The Energy Resources Institute.

U.S Environmental Protection Agency. (2016, 02 20). *Green Building.* Retrieved from EPA Home: https://archive.epa.gov/greenbuilding/web/html/about.html

UNAI. (n.d.). *Sustainability*. Retrieved from un.org: https://www.un.org/en/academic-impact/sustainability

UNESCO. (2021). *Sustainable Development*. Retrieved from unesco.org: https://en.unesco.org/themes/education- sustainable-development/what-is-esd/sd

WBDG Sustainable Committee. (2021, 09 08). *Sustainable* . Retrieved from wbdg.org: https://www.wbdg.org/design-objectives/sustainable

Wikipedia. (n.d.). *Plaster*. Retrieved from wikipedia.org: https://en.mwikipedia.org/wiki/Plaster

Wikipedia. (n.d.). *Polystyrene*. Retrieved from wikipedia.org: https://en.mwikipedia.org/wiki/Polystyrne

Wikipedia. (n.d.). *Thermal Contact Conductance*. Retrieved from wikipedia.org: https://en.m.wikipedia.org/wiki.Thrmal_con tact_conductance

World Green Building Council. (n.d.). *The benefits of green buildings*. Retrieved from worldgbc.org: https://www.worldgbc.org/benefits-green- buildings

Youmatter. (2020, 02 20). *Carbon Footprint Definition*. Retrieved from youmatter.world: https://youmatter.world/en/definition/definitions-carbon-footprint/

Yuksek, I., & Karadayi, T. T. (2017). Energy-efficient Building design in the context of building life cycle. In *Energy Efficient Buildings.* Intech- open science.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

Zigenfus, R. E. (2008). *Element analysis of the green building process.* Rochester Institute of Technologies. Accessed form.